



UNITED STATES

**TITLE:** METHOD AND DEVICE TO IMPROVE THE  
RATIO OF OXYGEN MASS VERSUS FUEL MASS  
AT IGNITION IN COMBUSTION MECHANISMS  
OPERATING WITH FLUID ~~HYDRO CARBON~~ HYDROCARBON FUEL

**INVENTOR:** WILLIAM H. VELKE



**FUEL DENSITY REDUCTION METHOD AND DEVICE TO IMPROVE  
THE RATIO OF OXYGEN MASS VERSUS FUEL MASS DURING IGNITION IN  
COMBUSTION MECHANISMS OPERATING WITH FLUID HYDROCARBON  
FUELS**

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**FIELD OF THE INVENTION**

The present invention relates to the improvement in combustion efficiency of conventional fluid hydrocarbon fuels, such as natural gas or propane gas and the like when employed as fuel for residential, commercial and industrial space heating or cooling equipment, or for process heating, smelting or generating equipment and turbines, whereby such combustion efficiency improvement is obtained through a change in the mass ratio of fuel versus combustion air such as to effectively increase the available oxygen mass relative to fuel mass during ignition.

**BACKGROUND OF THE INVENTION**

It is generally recognized that the combustion process of conventional fluid hydrocarbon fuels is improved if additional oxygen is introduced into the combustion air / fuel gas mixture at the time of ignition. It is further recognized that the manipulated infusion of additional oxygen into the combustion air / fuel gas mixture is only possible in connection with additional energy expenditure to perform such task.

The Transportation Technologies / Heavy Vehicles Industry is presently investigating the use of natural gas as an alternative fuel for the transportation sector. To improve the ~~power~~ power output of such natural gas engines, it is testing a second-stage intercooler for LNG (liquid natural gas) fueled heavy vehicles. The concept uses LNG fuel to cool the intake air to increase combustion air density relative to fuel density and thereby achieving better engine performance, but without stating any specific temperature level.

At present, it is still believed in the gas combustion appliance industry that pre-heating of fuel, as contemplated in this invention, is not ~~effective~~ effective to cause a fuel ignition improvement and thereby increase combustion dynamics. In fact, a correction formula is always employed in the industry to eliminate any variance in fuel efficiency calculations due to a change in fuel temperature or fuel density. Such correction formula calculation may be found in the "Gas Engineers Handbook", Ninth Printing, Chapter 8, "Gas Calorimetry", Pages 6-42.

Therefore, the method and device as disclosed in the present invention is completely contrary to industry norm, and is not at all obvious.

## **SUMMARY OF THE INVENTION**

The invention therefore discloses a method and device providing the present effect of reducing fuel density while at the same time maintaining or increasing combustion air density such as to significantly change the ratio of fuel mass versus combustion air mass. This provides a much improved method over the process considered with automotive natural gas combustion engines, employing only a combustion air intercooler. The present combination effect is generally achieved by pre-heating natural gas or propane gas, or other conventional fluid hydrocarbon fuels, as it is delivered to the mechanism's burner manifold, while at the same time maintaining or reducing combustion air temperature when operation today's typical residential, commercial and industrial combustion mechanisms and appliances incorporating a burner arrangement located in a combustion zone. This method is able to provide a significant amount of combustion dynamics improvement while at the same time reducing harmful flue gas emissions.

The present method incorporates a device, which is able to rely solely on heat, or waste heat, generated by the combustion mechanism as heat source for such fuel density reduction operation, consisting of the following basic components.

Referring now to **Figure 1** of the drawings, there is shown, in schematic view, a combustion mechanism with a burner arrangement **4** located in combustion area **3**. Incoming fuel is routed through fuel conduit **1** to the first heat exchanger **7** for the purpose of increasing the density of the combustion air **9** flowing through air inlet duct **8** for mixing with fuel at ignition in burner area **4**. The fuel is then routed from the first heat exchanger **7** through the second heat exchanger **6**, all equipped with insulation 12, designed for the purpose reducing the density of the fuel using waste heat from the combustion mechanism's flue stack area **10**. The density reduced fuel is then routed through an insulated conduit **2** to combustion area **3** for mixing with the density increased combustion air at ignition in burner area **4**. The fuel in this application is employed to provide the density increasing means at heat exchanger **7** for improving oxygen mass in the combustion air **9**. This is especially feasible when a fuel like liquid natural gas or propane and the like is used, which flows at low temperature and converts to a gaseous state at even lower temperature. Location **5** in the combustion mechanism always indicates the theoretical energy transfer or working area of the combustion mechanism.

In **Figure 2** of the drawings, there is shown again, in schematic view, a combustion mechanism with a burner arrangement **4** located in combustion area **3**. Incoming fuel is routed again through fuel conduit **1** to the first heat exchanger **7** for increasing combustion air density. From this location the fuel is routed through the second heat exchanger **6** which is now located adjacent the combustion area **3** of the combustion mechanism. This heating zone location allows for higher fuel heat exchange temperatures, resulting in maximum fuel density reduction.

In **Figure 3** of the drawings is shown a further schematic view of a combustion mechanism with a burner arrangement **4** located in combustion area **3**. The incoming fuel is now routed through conduit **1** directly to heat exchanger **6** from where it flows density reduced through insulated conduit **2** for mixing with combustion air and ignition at burner arrangement **4**. The combustion air **9** is now cooled by independent means at heat exchanger **7** connected to separate energy supply **11** such as to increase the density of air flowing through air duct **8** for mixing with fuel and ignition at burner arrangement **4**.